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REDESCRIPTION OF *DUGESIA ARIMANA* HYMAN, 1957, BASED UPON MATERIAL FROM TRINIDAD, ST. VINCENT AND VENEZUELA (Turbellaria, Tricladida, Paludicola)

by

MASAHARU KAWAKATSU and ROBERT W. MITCHELL

INTRODUCTION, MATERIALS AND METHODS

The description of *Dugesia arimana* HYMAN, 1957, was based on a single sexually mature specimen collected by HYMAN in the Arima River in Trinidad. Although she described the species well, her figures of the external appearance of the live specimen and the sagittal view of the copulatory apparatus were very simple. Afterward, BALL (1971) gave a detailed redescription of this species based upon HYMAN's slides of the holotype specimen as well as his own sections of animals from the St. Joseph River (near to the type locality).

We also had a chance to examine this species based upon the following materials.

1) KAWAKATSU's Specimen Lot No. 441A. Loc. The vicinity of Caracas in Venezuela (collected by the late Dr. Kôjirô KATÔ in 1962; cf. KAWAKATSU & MITCHELL, 1984). Two sexually mature specimens, fixed with Bouin's fluid, were prepared as serial sagittal sections and were stained with Delafield's hematoxylin and erythrosin.

2) KAWAKATSU's Specimen Lot No. 1107. Loc. Small underground pools in Tamana Cave, Central Range, Trinidad (collected by Dr. John A. L. COOKE in February, 1972). Seventeen sexually mature specimens, fixed with Bouin's fluid, were prepared as serial sagittal, horizontal, and transverse sections and were stained with Delafield's hematoxylin and erythrosin.

3) ROM C20 (2 slides of serial sagittal sections). Identified, loan material from the Royal Ontario Museum, Canada, by courtesy of Dr. Ian R. BALL in 1973. Loc. The St. Joseph River, east of Port-of-Spain, Trinidad (collected by Dr. H. B. N. HYNES on December 16, 1969; cf. BALL, 1971).

4) ROM C21 (2 slides of serial sagittal sections) and C22 (3 slides of serial sagittal sections). Identified, loan material from the ROM by courtesy of Dr. BALL in 1973. Loc. St. Vincent, West Indies (collected by Dr. A. D. HARRISON on August 14, 1972; the sample seems to have been collected from one of the localities listed in a paper by HARRISON & RANKIN, 1976).

The purpose of the present paper is to give a redescription of *Dugesia arimana* from the above-mentioned 4 localities for comparison of the local variations in its morphology and genital anatomy, together with zoogeographical discussions on this Caribbean species.

SPECIES DESCRIPTIONS

Order TRICLADIDA

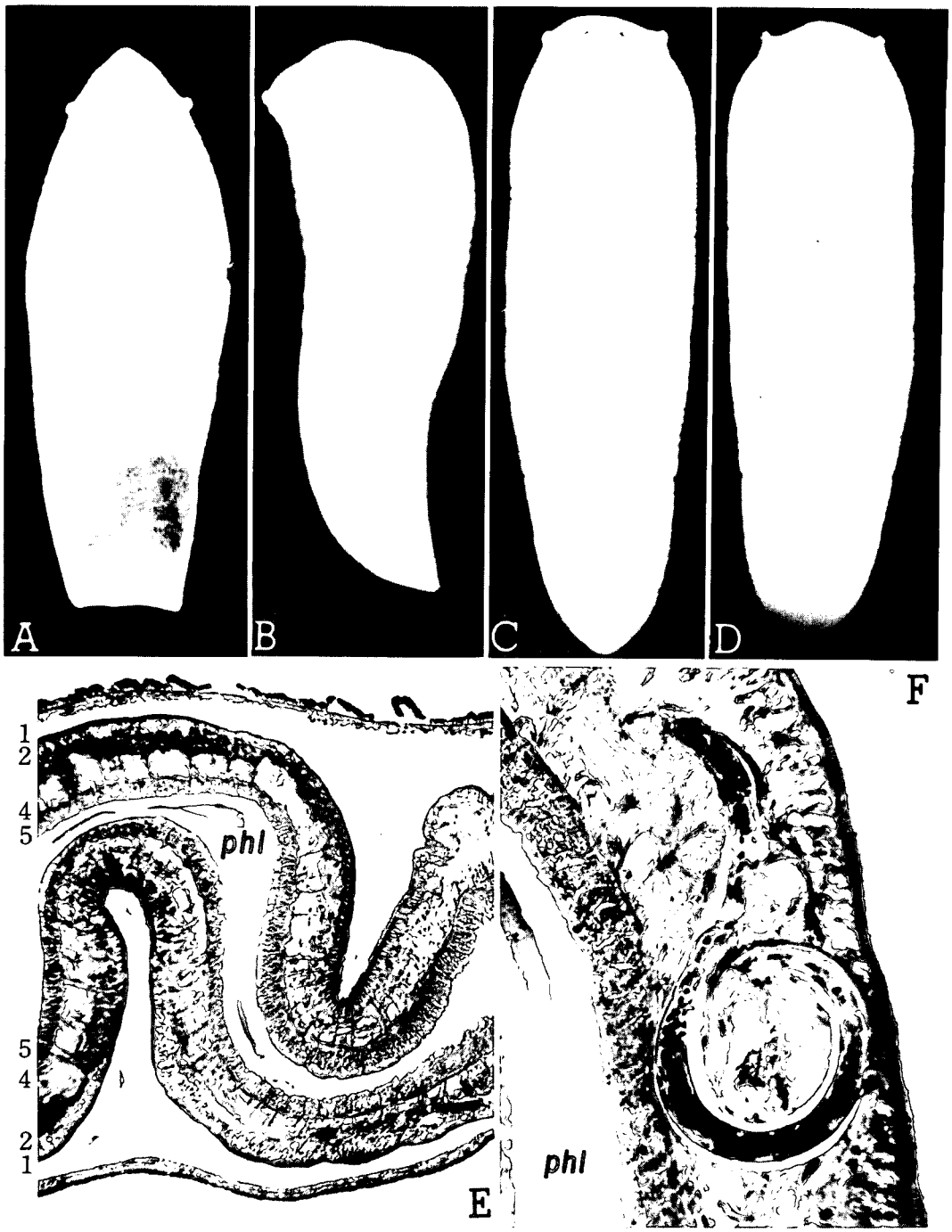


Fig. 1. *Dugesia arimana* HYMAN, 1957. A-D : Photographs of 3 preserved specimens from Tamana Cave in Trinidad (Specimen Lot No. 1107). A and C, dorsal views ; B, ventral view ; D, ventral view of the Specimen C. E and F : Photomicrographs of sagittal pharyngeal sections of the specimen from Caracas in Venezuela (Lot No. 441A-a). F, a parasitic Nematode species (enlarged). **phl**, pharynx lumen. **1**, longitudinal fibers of outer muscle zone ; **2**, circular fibers of outer muscle zone ; **4**, longitudinal fibers of inner muscle zone ; **5**, circular fibers of inner muscle zone.

Suborder PALUDICOLA or PROBURSALIA
Family Dugesiidae BALL, 1974
Genus *Dugesia* GIRARD, 1850

Dugesia arimana HYMAN, 1957

Principal literature : HYMAN, 1957 ; BALL, 1971, 1974, 1980 ; KENK, 1974.

External features. — Three sexually mature, preserved specimens from the Tamana Cave locality are shown in Fig. 1 (A-D). Well preserved specimens measure approximately 10 to 15 mm long by 2 to 2.5 mm wide. The head is triangular with rather broad, moderately long auricles. A pair of eyes, each surrounded by a clear non-pigmented ocular area, are conspicuous ; the distance between them is nearly one-third of the width of the head at the level of eyes. The posterior end of the body is rather pointed.

The rather long pharynx is inserted at about the middle of the body. The genital pore opens on the midline at the anterior one-fourth of the postpharyngeal region. Our observations agree better with the figure and description by BALL (1971, pp. 3-4, fig. 1) than that of HYMAN's sketch (1957, p. 3, fig. 1) of the live specimen. From the ventral side of the body, spermiducal vesicles can easily be seen as a pair of opaque, swollen organs located on either side of the anterior part of the copulatory apparatus and the posterior part of the pharynx (Fig. 1 D).

The color of the dorsal surface of the Tamana Cave specimens is uniform pale brown with a narrow, brownish middorsal longitudinal line in the prepharyngeal region ; the margin of the body and the areas above the pharynx and the copulatory apparatus are of a lighter hue. The paired, white auricular sensory organs are conspicuous. The ventral surface of the body is of a lighter hue than that of the dorsal. The external appearance of the Caracas specimens is essentially similar to that of the Tamana Cave specimens (the coloration of the former was dark brown, perhaps due the effect of chemicals).

Internal features. — In the Tamana Cave specimens, the anterior intestinal trunk has 13 to 15 branches on each side ; each posterior trunk has 15 to 18 short lateral branches. The pigmentaion of the surface of the pharynx was not examined. The musculature of the pharynx shows the typical arrangement of the genus *Dugesia*. The external musculature of the pharynx consists of two layers, *i. e.*, an outer thin layer of longitudinal fibers and an inner, slightly thickened layer of circular ones (Fig. 1 E). In one of the Caracas specimens (Lot No. 441A-a), a parasitic Nematode species was found in the pharyngeal tissue (Fig. 2 F).

A pair of ovaries occurs in the usual ventral position. Numerous yolk glands (or vitellaria) are distributed throughout the body (Fig. 2 A). Testes are moderate to large in size (especially in the Caracas specimens) and essentially occupy the dorsal part of the mesenchyme, extending from the posterior (sometimes just anterior) level of ovaries nearly to the posterior end of the body (Figs. 2 A ; 3 A-D ;

Fig. 2. *Dugesia arimana*, photomicrographs of sagittal sections of 2 specimens from 2 localities. A : Near midsagittal section of the prepharyngeal region of a specimen from the Caracas locality (Lot No. 441A-a). B : Sagittal section of copulatory apparatus of a specimen from the Tamana Cave locality (Lot No. 1107-b). **bs**, bursa stalk ; **br**, brain ; **cb**, copulatory bursa ; **ed**, ejaculatory duct ; **gp**, genital pore ; **i**, intestine ; **ma**, male genital antrum ; **nc**, nerve cord ; **o**, ovary ; **od**, ovovitelline duct ; **pb**, penis bulb ; **pp**, penis papilla ; **t**, testis ; **yg**, yolk gland.

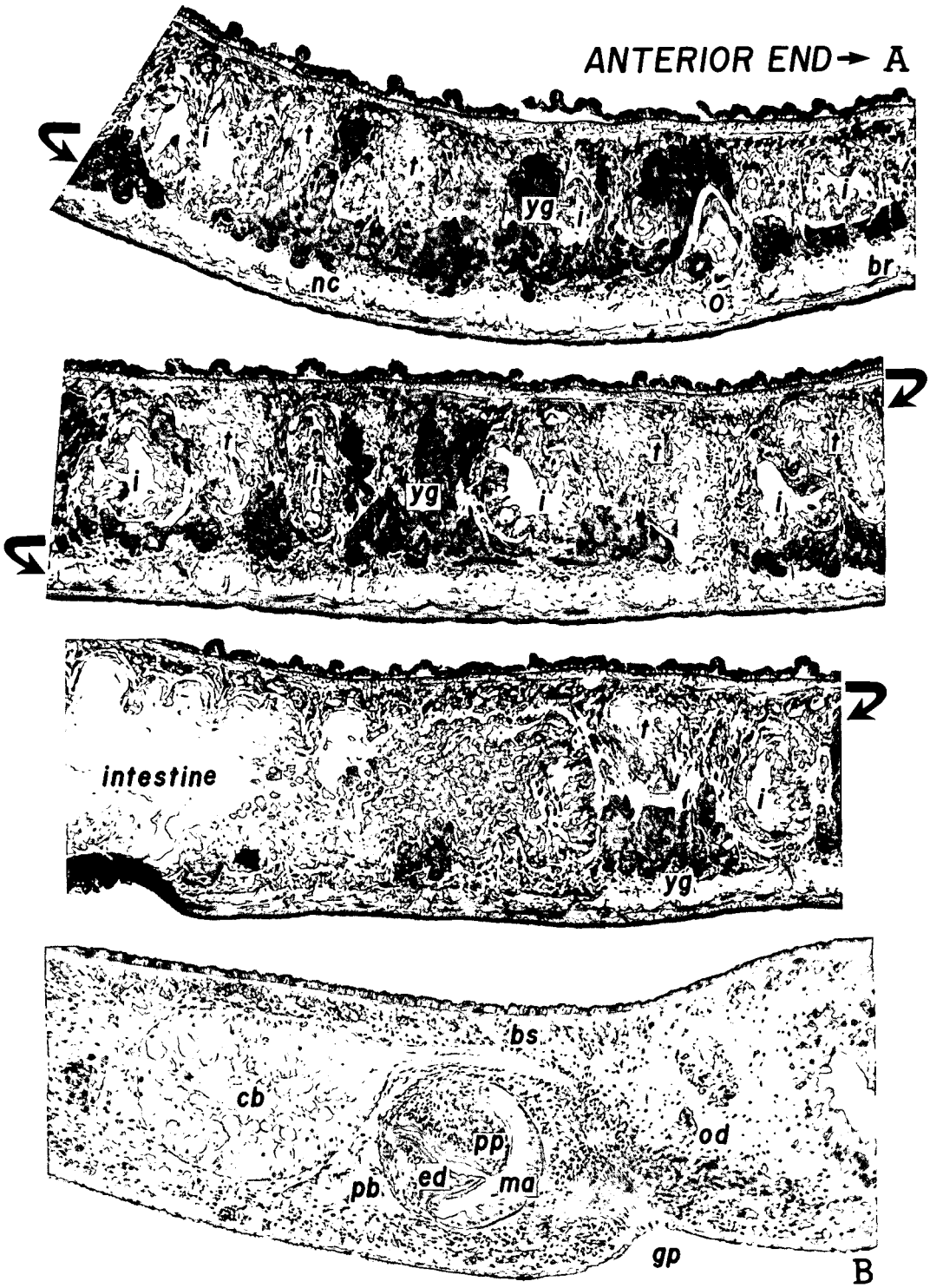


Fig. 2. For explanation see page 65.

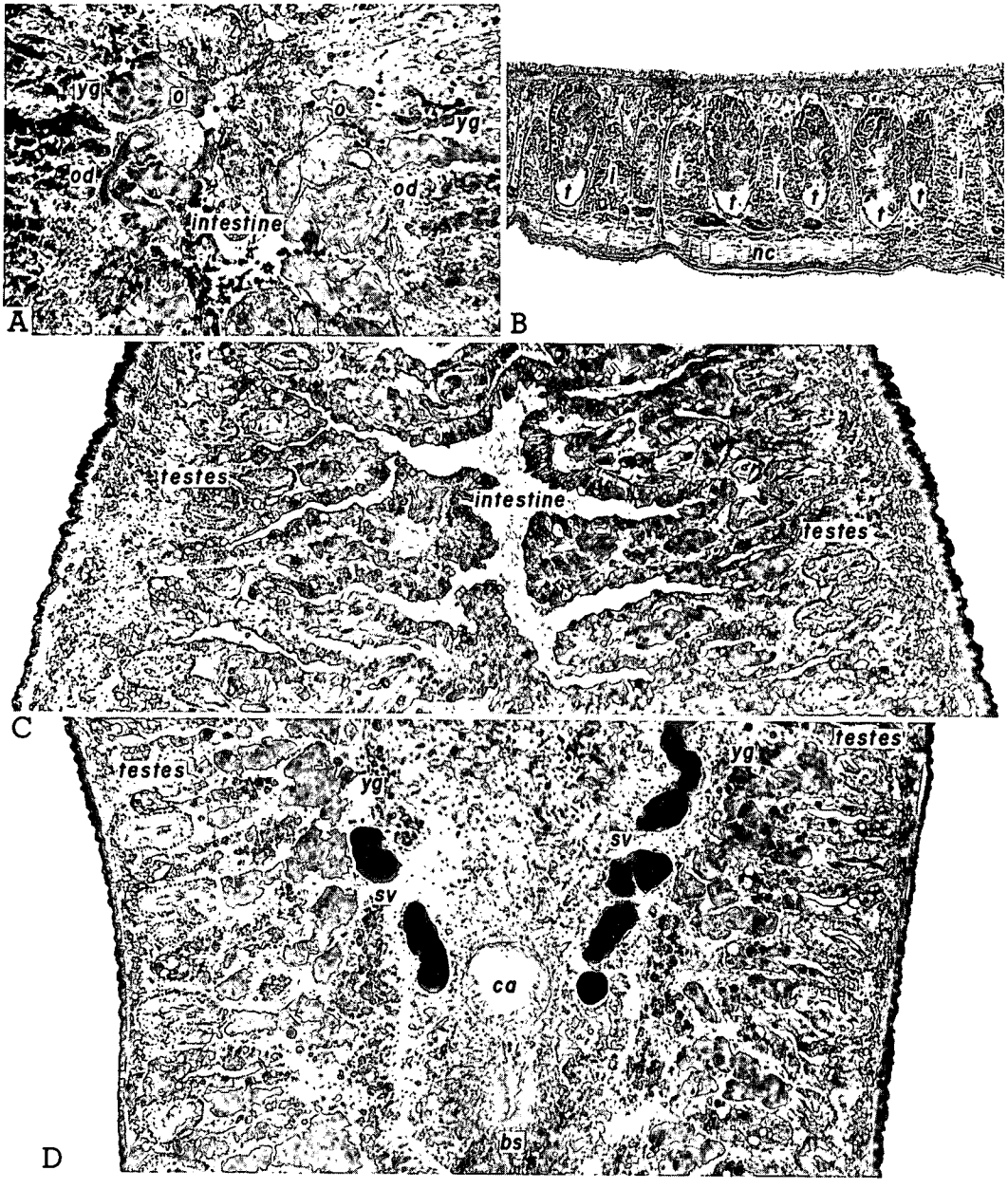


Fig. 3. *Dugesia arimana*, photomicrographs of horizontal sections (A, C and D) and sagittal section (B). A : Anterior part of the prepharyngeal region of a specimen from the Tamana Cave locality (Lot No. 1107-o). B : Middle part of the prepharyngeal region of a specimen from St. Vincent (ROM C-21). C and D : Parts of the prepharyngeal region (C) and the postpharyngeal region (D) of a specimen from the Tamana Cave locality (Lot No. 1107-o). **bs**, bursa stalk ; **i**, intestine ; **ma**, male genital antrum ; **nc**, nerve cord ; **o**, ovary ; **od**, ovovitelline duct ; **sv**, spermiducal vesicle ; **t**, testis ; **yg**, yolk gland.

4 A and B). The large testes occupy almost two-thirds of the dorsoventral space (Fig. 3 B). A few small testes are also found in nearly ventral positions. In the prepharyngeal region, they are arranged on either side of the midline in 2 to 3 longitudinal zones; in the prepharyngeal and the postpharyngeal regions, they are arranged in one to 2 longitudinal zones (Figs. 3 A, C and D; 4 A and B). Their total number is estimated at about 200 in the large Tamana Cave specimens. Our observations correspond with those of BALL's (1971, p. 6).

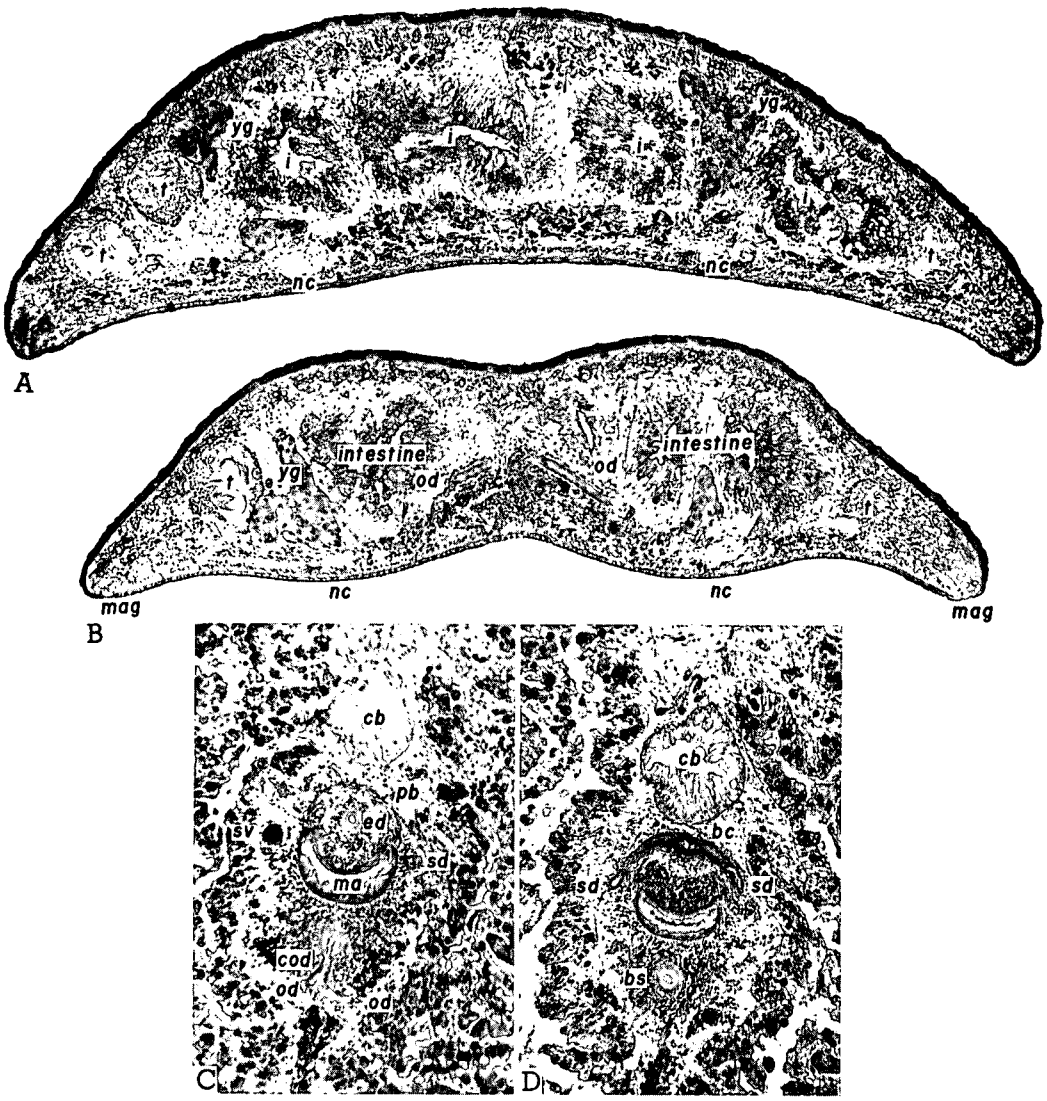
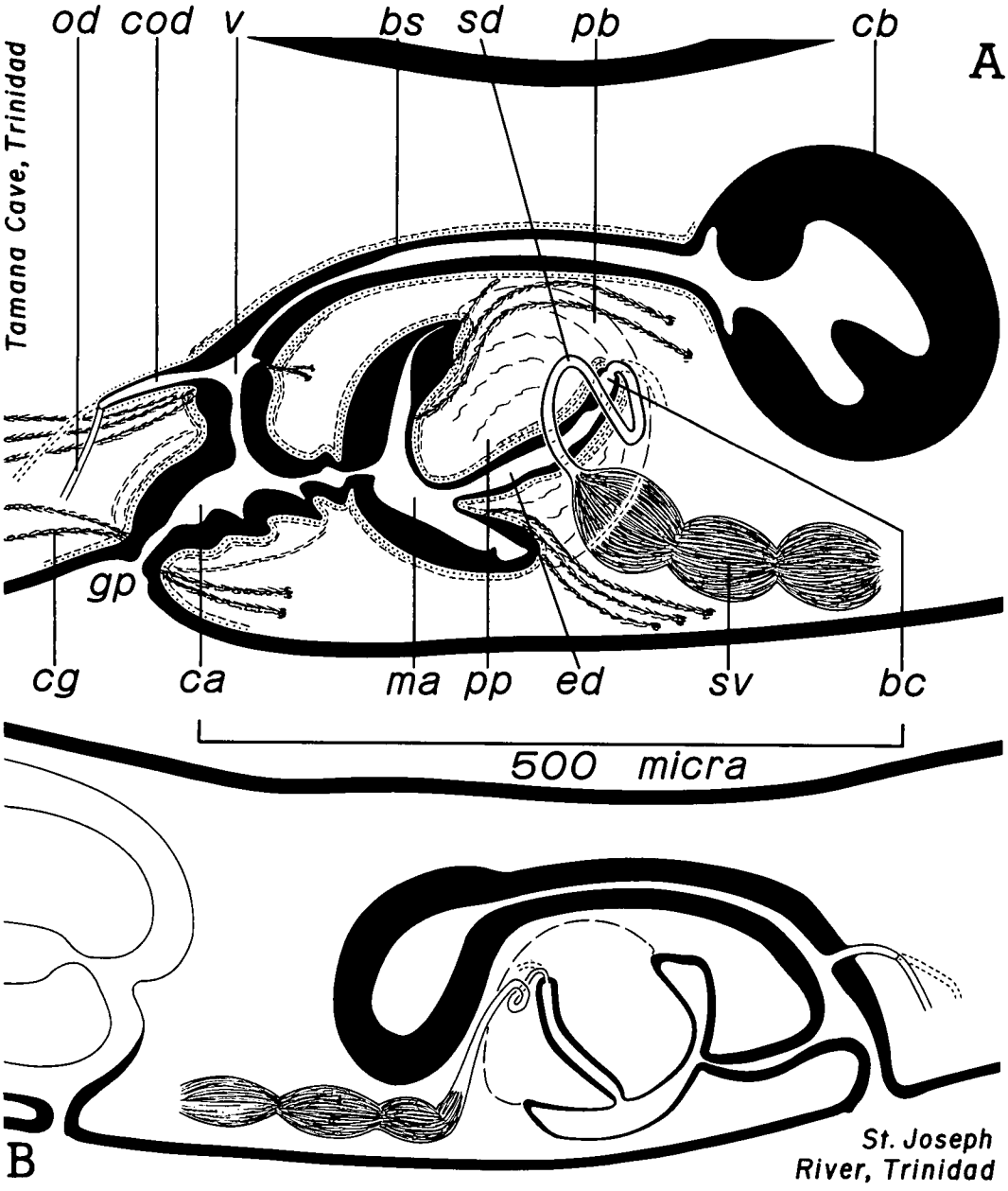


Fig. 4. *Dugesia arimana*, photomicrographs of transverse sections (A and B) and horizontal sections (C and D) of 2 specimens from the Tamana Cave locality. A: Anterior part of the prepharyngeal region (Lot No. 1107-p). B: Posterior part of the postpharyngeal region (Lot No. 1107-p). C and D: Copulatory apparatus (Lot No. 1107-o). **bc**, bulbar cavity; **bs**, bursa stalk; **cb**, copulatory bursa; **cod**, common ovovitelline duct; **ed**, ejaculatory duct; **ma**, male genital antrum; **mag**, marginal adhesive gland; **nc**, nerve cord; **od**, ovovitelline duct; **sd**, sperm duct; **t**, testis; **yg**, yolk gland.

Sagittal views of the copulatory apparatus of 4 specimens from the 4 localities are shown in Fig. 5 (A-D). Pertinent photomicrographs of the copulatory apparatus of several specimens from these localities are also shown in Figs. 2 (B), 3 (D), 4 (C and D), and 6 (A-O).

Because the anatomy and histology of the copulatory apparatus of the holotype and the St. Joseph River specimens in Trinidad were well described by BALL (1971, pp. 4-7, figs. 2, 3 and 4), we give here only a concise summary of our observations. The penis bulb is hemiglobose in shape. A conspicuous bulbar cavity is not differentiated in this species. Each sperm duct recurves on either side of the posterolateral portion of the penis bulb and opens separately into the begining of the penis lumen (Fig. 5 A-D). The penis papilla is of a rather short, bluntly pointed conical form in the specimens from



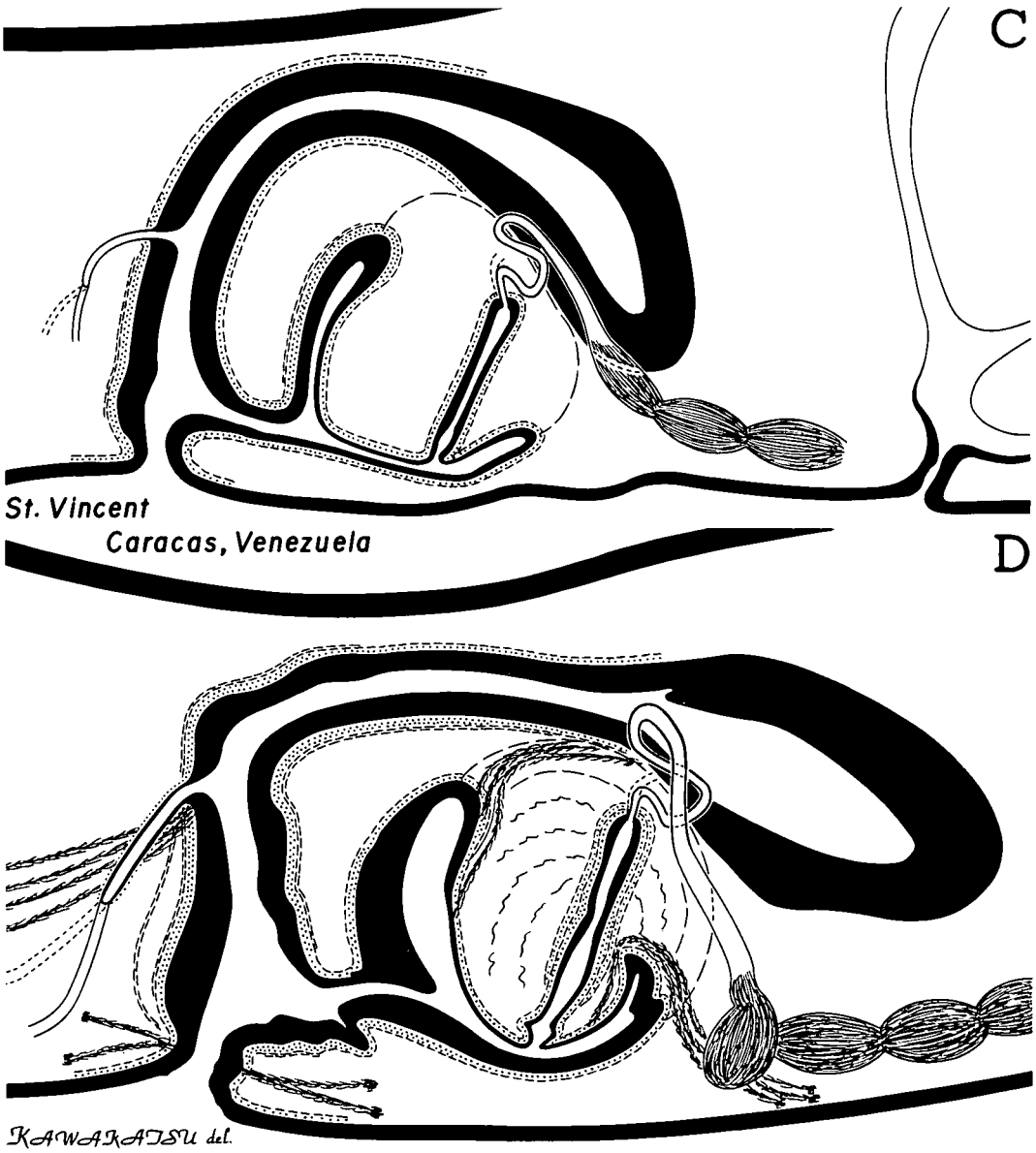


Fig. 5. *Dugesia arimana*, semidiagrammatic sagittal views of the copulatory apparatus of 4 specimens from 4 localities. A : Tamana Cave in Trinidad (Lot No. 1107-g). B : The St. Joseph River in Trinidad (ROM C20). C : St. Vincent (ROM C21). D : Caracas in Venezuela (Lot No. 441A-a). **bc**, bulbar cavity ; **bs**, bursal stalk ; **ca**, common genital antrum ; **cb**, copulatory bursa ; **cg**, cement gland ; **ed**, ejaculatory duct ; **gp**, genital pore ; **ma**, male genital antrum ; **od**, ovovitelline duct ; **pb**, penis bulb ; **pp**, penis papilla ; **sd**, sperm duct ; **sv**, spermiducal vesicle ; **v**, vagina.

2 localities in Trinidad and St. Vincent (Figs. 2 B ; 5 A, B and C ; 6 A-M). In the Caracas specimens, the slightly asymmetrical penis papilla is rather large and hemiellipsoidal in shape (Figs. 5 D ; 6 N and O). The ejaculatory duct is a long, narrow, tubular cavity that opens on the ventral side of the penis papilla near its tip (Fig. 5 B and C ; see photomicrographs). The specimens from the Tamana Cave and

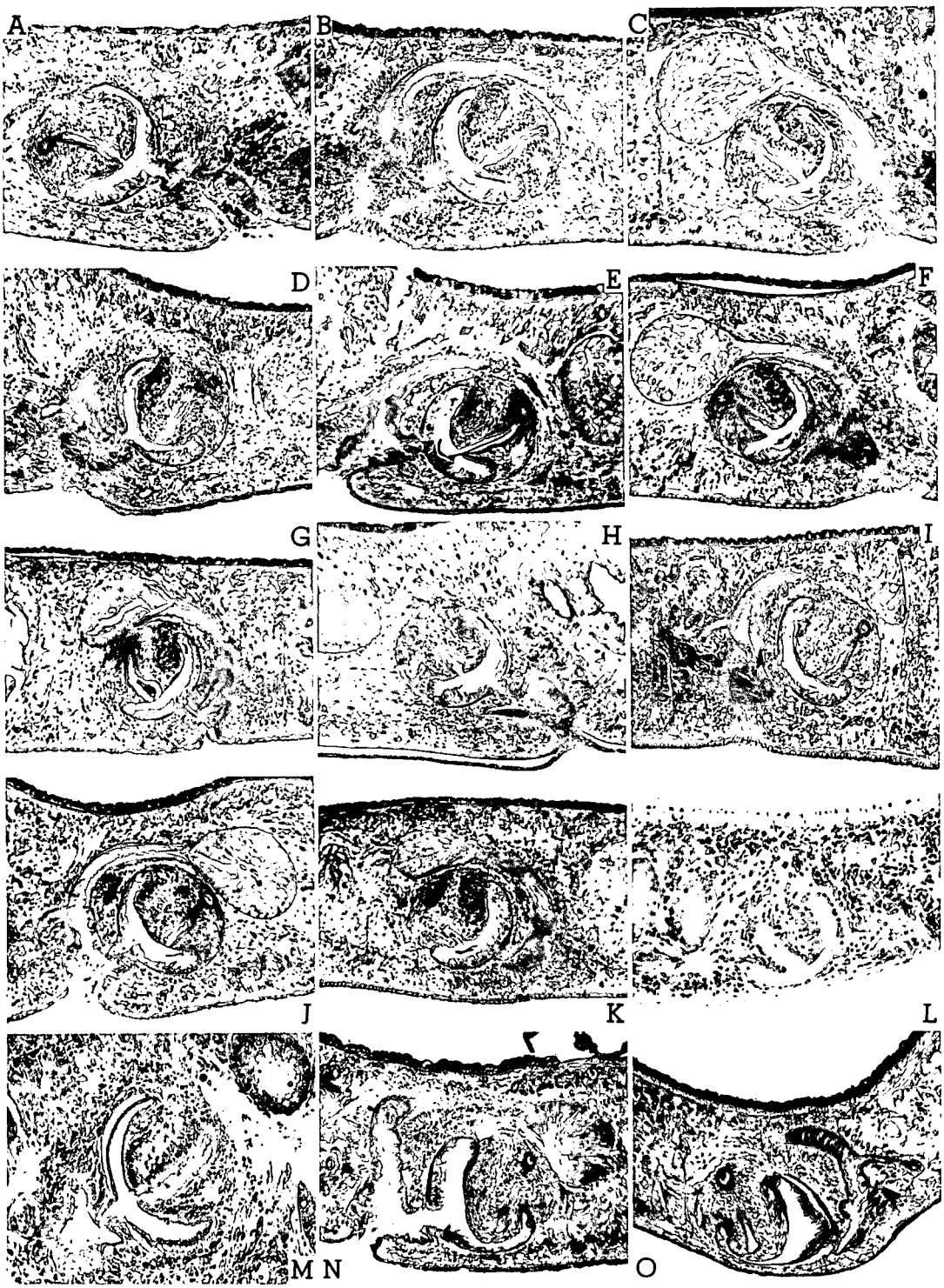


Fig. 6. *Dugesia arimana*, photomicrographs of sagittal sections of the copulatory apparatus of 15 specimens from 4 localities. A-K : Tamana Cave (Lot No. 1107). A, 1107-a ; B, 1107-c ; C, 1107-d ; D, 1107-e ; E, 1107-g ; F, 1107-h ; G, 1107-i ; H, 1107-j ; I, 1107-k ; J, 1107-m ; K, 1107-n. L : St. Joseph River (ROM C20). M : St. Vincent (ROM C22). N and O : Caracas (Lot No. 441A). N, 441A-a ; O, 441A-b.

the Caracas localities have a rather wide, tubular ejaculatory duct (Fig. 5 A and D; see photomicrographs). The male genital antrum, a cup-shaped cavity, is sharply separated from the common genital antrum by a narrow, tubular cavity in every specimen examined (Fig. 5 A-D; see photomicrographs). Spermiducal vesicles are well developed in this species (Figs. 3 D; 4 C and D; 5 A-D).

The copulatory bursa is moderate in size with a long, narrow, or sometimes slightly widened (especially in the St. Vincent specimen) bursal stalk that opens into the common antrum from the dorsal side. The posterior, terminal portion of the bursal canal receives a short common ovovitelline duct from its posteroventral direction (Fig. 4 B and C). Its opening is usually located at a high position (Figs. 5 A-D; 6 D, E, I, J, and L).

A normal nucleate, glandular epithelium is found in the areas of the common and male genital antra, the basal part of the penis papilla, and the copulatory bursa. The remaining parts of the copulatory apparatus (penis lumen, most of the penis papilla, and the bursal canal) are covered with an infranucleate epithelium. The subepithelial musculature surrounding the penis lumen is more developed in the specimens from the Tamana Cave and the Caracas localities than that of the specimens from the St. Joseph River and the St. Vincent localities.

Localities and disposition of the materials. — Two sets of serial sagittal sections of the Caracas specimens (Specimen Lot No. 441A a and b); 17 sets of serial sagittal, horizontal and transverse sections of the Tamana Cave specimens (Specimen Lot No. 1107 a-q). The other data of the specimens examined are listed in the foregoing section of the present paper.

Two sets of sections (Lot No. 1107 b and p) are deposited in the U. S. National Museum of Natural History, Smithsonian Institution, Washington, D. C. Three other sets of sections (Lot No. 1107 g, h and o; NSMT-pl 2971) are deposited in the Department of Zoology (Nat. Hist.), National Science Museum, Tôkyô. The remaining sections are retained in KAWAKATSU's laboratory in Sapporo (one set of sections of the Tamana Cave specimen separated from this collection will be sent to Dr. J. KENNY, Zoology Department, the University of West Indies, St. Augustine, Trinidad).

ECOLOGICAL NOTE ON THE TAMANA CAVE LOCALITY AND FAUNISTIC REMARKS ON CARIBBEAN FRESHWATER PLANARIANS

Information about the Tamana Cave System has come to us from Dr. J. S. KENNY (1979 and Pers. Comm.) and from Dr. J. A. L. COOKE (Pers. Comm.). The cave in which Dr. COOKE collected the planarians discussed herein is one of two caves in the "Tamana Cave System." It is designated by Dr. KENNY (1979) as the "Tamana Main Cave" or, simply, as "Tamana Cave." The cave is situated on the northern face of Mt. Tamana at about 240 meters in altitude in the Central Range of Trinidad. The System occurs in a uniform Miocene algal limestone that has been subjected to intense disturbance. Floor plan and some important cave features are shown in Fig. 7. The stream in the cave is of extremely variable discharge and almost disappears during the dry season (January-May), but there is always some water in the deep part of the cave. In the upper part of the cave, water temperature is stable at 24°C throughout the year, but in the deep part of the cave, it may rise to as high as 31°C during the dry season when stream flow is reduced.

The stream supports a fauna consisting mainly of tadpoles of *Phyllobates* in the upper part of the cave and flatworms (planaria; undetermined) in the lower part (cf. KENNY, 1979). Dr. KENNY also informed us as follows: "We have not actually done counts but there is no doubt that the flatworms are extremely numerous. It would be impossible to collect a 100 ml. sample of stream sediments without obtaining at least 50 specimens. They live incidently on and in the stream sediments and swarm in large

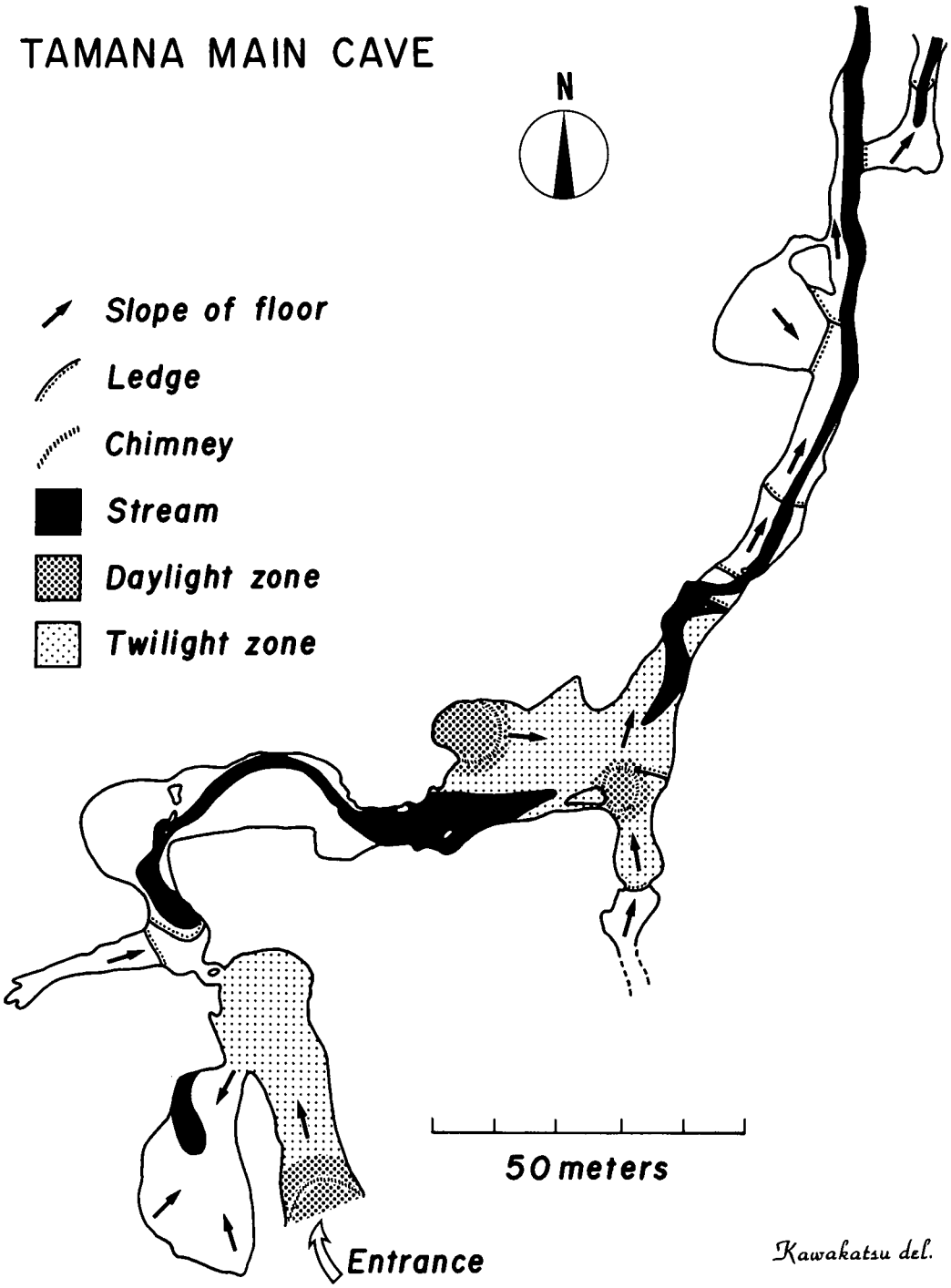


Fig. 7. Sketch map showing the floor plan and environment in Tamana Main Cave (after KENNY, 1979; modified).

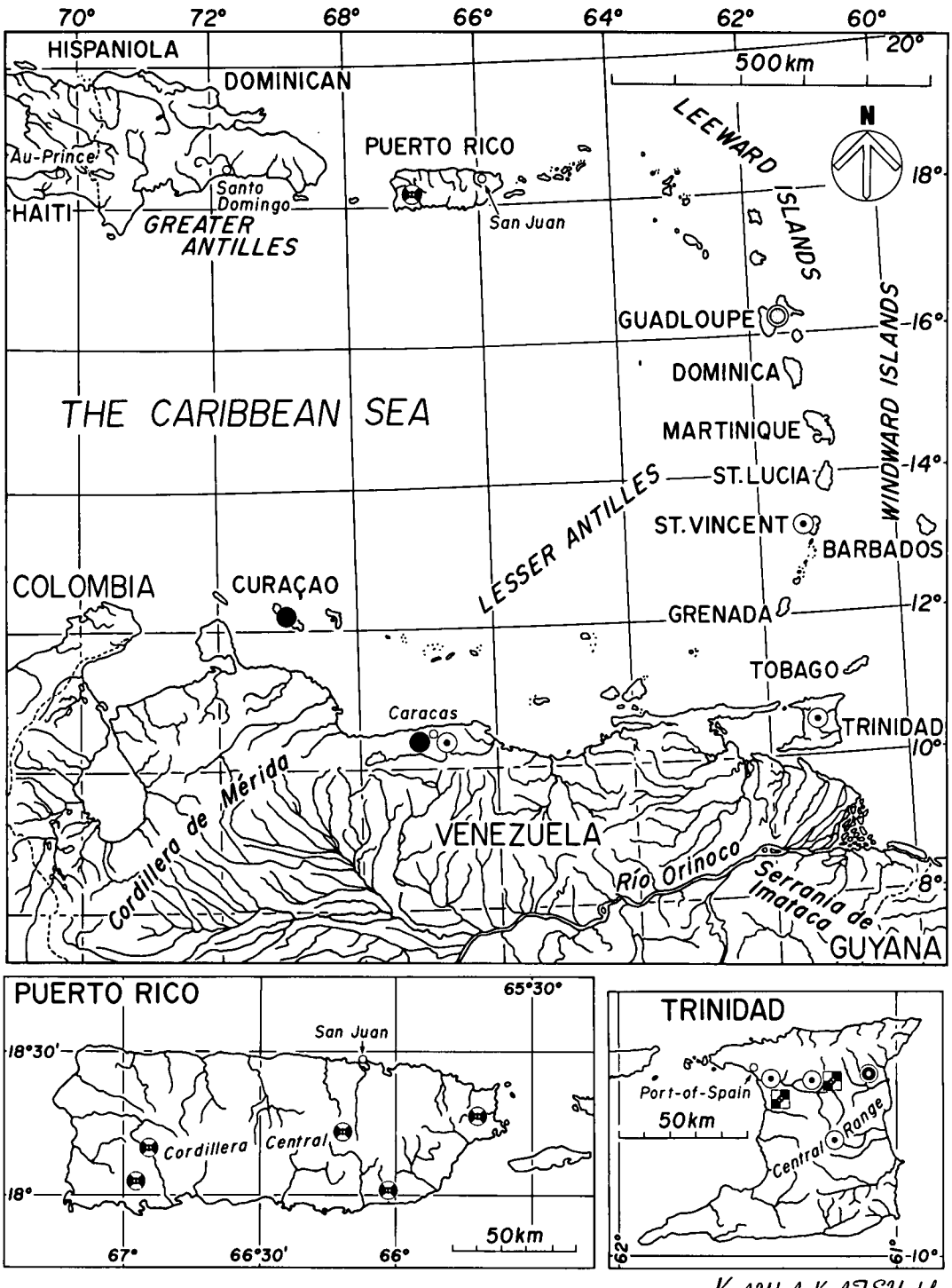


Fig. 8. Sketch map of the eastern half of the Caribbean Sea, showing the known localities of freshwater planarians. Enlarged maps of Puerto Rico and Trinidad are also shown. Several localities lying close together in one district are represented by a single symbol. For records of several undetermined species, see text.

numbers over the decaying bodies of bats."

According to Dr. COOKE, the pools in which the planarians were collected are about 46 meters from the entrance shaft, and although part of a stream system with a good flow, the water of the pools was thick with bat guano. Dr. COOKE's collecting locality was probably in the Boulder Chamber or the Round Chamber (KENNY's 1979 nomenclature on his map).[1)]

To the present, the following 7 species of freshwater planarians are known from the Caribbean Islands and Venezuela. They are as follows: *Dugesia cubana* CODREANU et BALCESCO, 1973, from Cuba (see also GOURBAULT, 1979); *Dugesia antillana* KENK, 1941, from Puerto Rico; *Dugesia miltgeni* GOURBAULT, 1980, from Guadeloupe; *Dugesia arimana* HYMAN, 1957, from Trinidad, St. Vincent and Caracas in Venezuela; *Dugesia festai* (BORELLI, 1898) from Curaçao (cf. MARCUS, 1960) and Caracas (cf. KAWAKATSU & MITCHELL, 1984); *Dugesia* (olim *Planaria*) *aurita* (KENNELL, 1888) from Trinidad (species inquirenda; cf. KENK, 1974, p. 22); "*Planaria*" *fissipara* KENNELL, 1888, from Trinidad (spesies inquirenda; cf. KENK, 1974, p. 47).

The records of several undetermined species that may belong to the genus *Dugesia* are also reported; *e. g.*, *Dugesia* sp. from Haïti (Haiti in Hispaniola; cf. GOURBAULT, 1980, p. 751); a species of triclad paludicola from Santo Domingo (Hispaniola; cf. KENK, 1941, p. 6); *Dugesia* sp. from St. Vincent (cf. BALL, 1971, pp. 16-17; probably *D. arimana*); *Dugesia* sp. from Trinidad (cf. BALL, 1971, p. 17; probably *D. arimana*); *Dugesia* sp. from Barro Colorado Island in the Canal Zone, Panama (cf. HYMAN, 1957, p. 4).

Taxonomic reviews of the Caribbean *Dugesia* species are found in papers by BALL (1971, 1980) and GOURBAULT (1979, 1980). The taxonomy of *Dugesia festai* is discussed in our recent paper (KAWAKATSU & MITCHELL, 1984). Therefore, we add here a sketch map showing the localities of freshwater planarians in only the eastern area of the Greater Antilles, the Lesser Antilles, and the northern part of Venezuela (Fig. 8). Although *Dugesia arimana* has a geographical range of approximately 700 kilometers in the Lesser Antilles and Venezuela, the degree of the local variation in its morphology and genital anatomy is minor.

ACKNOWLEDGEMENTS

We wish to thank the late Dr. Kôjiro KATÔ for giving us the material from Venezuela; to Dr. John A. L. COOKE, arachnologist and former Curator of the Arachnida, American Museum of Natural History, New York, N. Y., U. S. A., for supplying valuable specimens from Tamana Cave and the information of the cave locality. We also thank Prof. Dr. Ian R. BALL, Zoölogisch Museum Amsterdam, Universiteit van Amsterdam, Holland, for the loan of the slides of the identified specimens from Trinidad and St. Vincent. We are also indebted to Dr. Roman KENK, U. S. National Museum of Natural History, Smithsonian Institution, Washington, D. C., U. S. A., for supplying us with information on the collecting sites of *D. antillana* in Puerto Rico. Our thanks are also due to Prof. Dr. J. S. KENNY of the Department of Zoology, the University of the West Indies, St. Augustine, Trinidad, the Republic of Trinidad and

1) Dr. COOKE's photograph showing many live specimens of freshwater planarian (*Dugesia arimana*) in Tamana Cave is found on page 68 of PALMER & GOODENOUGH's 1978 paper.

 : *Dugesia antillana* KENK, 1941;  : *Dugesia miltgeni* GOURBAULT, 1980;  : *Dugesia arimana* HYMAN, 1957;  : *Dugesia festai* (BORELLI, 1898);  : *Dugesia aurita* (KENNELL, 1888);  : "*Planaria*" *fissipara* KENNELL, 1888.

Tobago, for supplying us with information on Tamana Cave as well as for his permission to include in our paper a sketch map of the cave modified from original maps in his 1979 paper. Thanks are also due to the members of the staff of the Japanese Embassy at Port-of-Spain for their kind effort.

SUMMARY

Redescription of *Dugesia arimana* HYMAN, 1957 (Turbellaria, Tricladida, Paludicola), is given in the present paper based upon material from Trinidad (Tamana Cave and the St. Joseph River), St. Vincent, and Caracas in Venezuela. Although this species is distributed rather widely in the southeastern area of the Lesser Antilles and Venezuela, the degree of the local variation in its morphology and genital anatomy is minor.

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Note added in proof. Since this manuscript went to the press, Dr. R. KENK has kindly sent a copy of HILL's 1981 paper. *Dugesia arimana* of Tamana Cave was observed also by that author, who mentioned "Planarian worms" on page 245 of his paper :

HILL, S. B., 1981. Ecology of bat guano in Tamana Cave, Trinidad, W. I. Proc. Eighth Intern. Congress of Speleol., Vol. I and II : 243-246.

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